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GB 2239211 A GB 1443830 A EP 0247952 A1
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(54) Abstract Title
Air cargo nets

(57) Air cargo nets are disclosed which are made from slit film polymer line, suitably from polypropylene or high density polyethylene. Such materials offer a lesser reduction in breaking strength due to knots or some other joints in the netting lines than multi-filament lines which have hitherto been used for air cargo net manufacture, and consequently for the same net strength, a lighter line can be used with consequential weight savings. This allows an increase in aircraft payload, and an increase in the aircraft fuel economy. Preferably, the slit-film polymer is formed into a braided cord for forming the net.

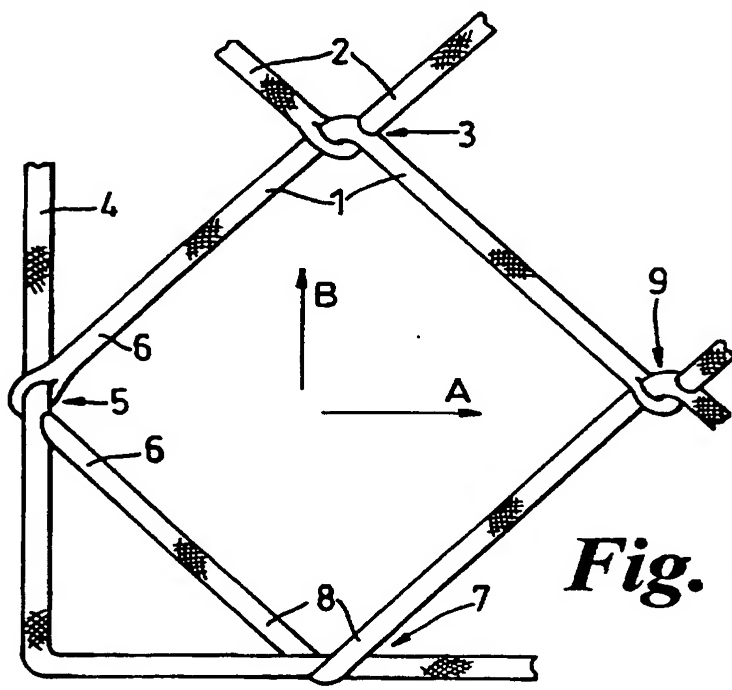

Fig. 1

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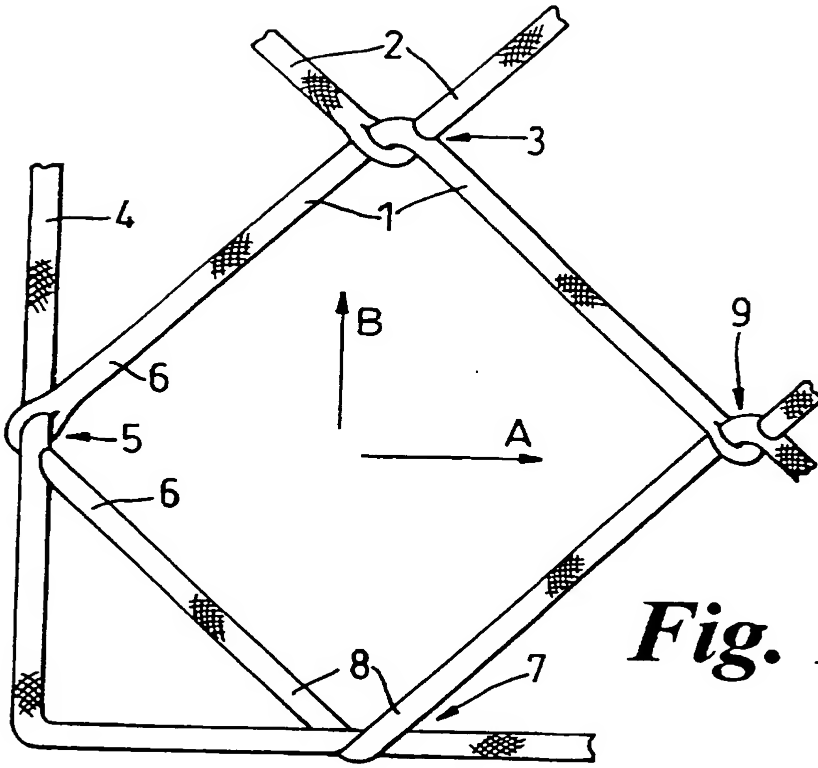

Fig. 1

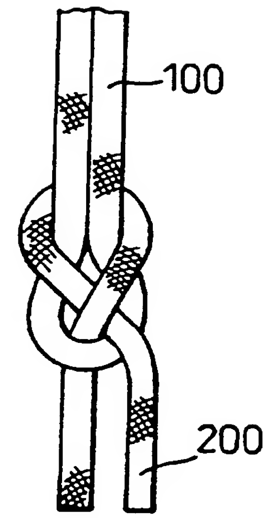

Fig. 3

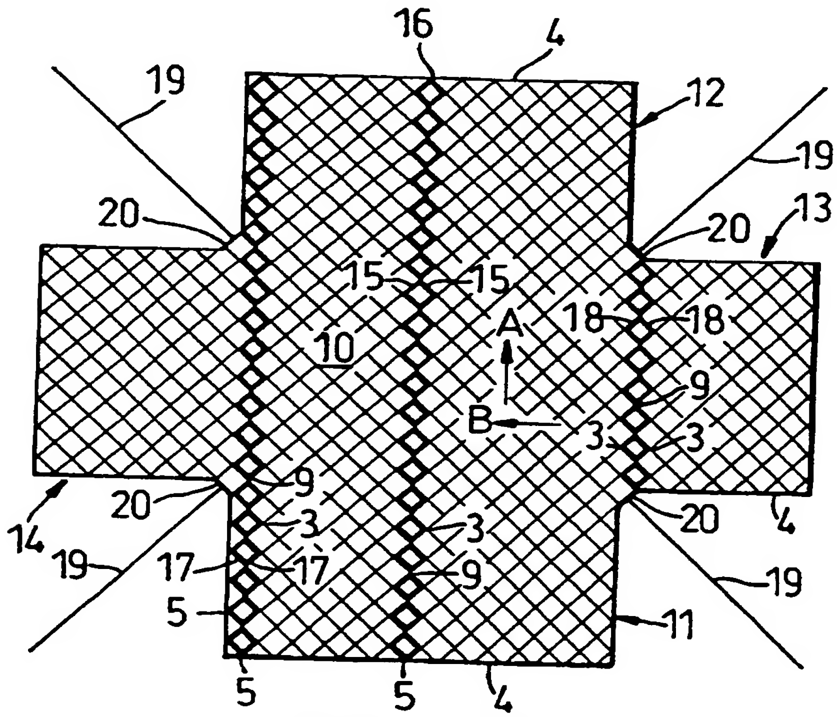

Fig. 2

AIR CARGO NETS

This invention relates to air cargo nets, that is to say, to nets of the types which are adapted for lashing aircraft cargoes against shifting during transport.

A typical example of an air cargo net designed for anchoring a load onto a pallet is cruciform in shape. The net has a rectangular central portion of about the same size and shape as the pallet, and four rectangular lobes which project from that central portion by a distance equal to the maximum load height of the pallet. To secure the load, the net is placed over the load and the net lobes are brought down; the ends of the lobes are secured to the sides of the pallet and the sides of the lobes to each other. Any slack in the net is taken up by hook-like tensioning devices.

It will be appreciated that such a cargo net must be strong enough to restrain a load from shifting on a pallet during flight, for example under the influence of forces due to atmospheric turbulence. Indeed there are standards laid down by such bodies as the Federal Aviation Authority in the United States of America, the Civil Aviation Authority in the United Kingdom, and the International Air Transport Association which such cargo nets must meet if they are to be used commercially.

It will also be appreciated that such cargo nets should be as light as possible in order not to displace an unduly large part of the payload of an aircraft.

In order to achieve the best compromise between high strength and low weight, it has been the practice to make the nets from polyamide (nylon) or polyester fibre in the form of a multi-filament yarn. The yarn is usually

made up into braided, woven or twisted cord or into webbing straps and the net is formed by joining such lines at intervals to form the net.

Attention has also been paid to the form of the joints. In some instances traditional knotted joints have been used, but considerable commercial success has been enjoyed by nets constructed in accordance with US-A-4,000,344 and GB-A-1,443,830, in which joints between netting lines are formed by passing each line as a body through a hole in the other line to form a so-called knotless or interpenetrating joint as shown in Figure 1 of this specification. Such a hole may be made in the netting line during manufacture of the net, or it may be pre-formed, for example as a slit formed during weaving of a webbing strap.

Joints of this interpenetrating type are less bulky than knots and thus take up less material, contributing to the lightness of the net as a whole, and because they are less bulky, they are also less prone to abrasive wear. A further important advantage of such interpenetrating joints is that they can have a reduced deleterious effect on the strength of the net than do conventional knotted joints.

It is well known that any twist, kink or knot in a rope, cord, strap, or other line will tend to reduce the ultimate tensile strength of that line. This has been attributed to the presence of more or less tight curvatures exhibited by the line at such a knot and to this acting as a stress raiser: however, the problem is more complicated than that since it is often found that when a knotted line is tested to breaking, it will fail close to, but not actually at, the knot. Be that as it may, twists, kinks and knots, and indeed other irregularities in, for example, a netting line of a known air cargo net, such as may be found at a joint, do in fact have a weakening effect in that the tensile strength across the net is less than the tensile strength of an

equivalent number of netting lines. Also, the strength of the net may depend on the direction across the net in which that strength is measured.

This invention is directed to the problem of failure of netting lines under tension. It is a particular object of this invention to provide a net in which the formation of joints between lines of the net does not have such a great weakening effect.

According to this invention there is provided an air cargo net, at least the majority of whose netting lines are made from slit-film polymer.

The invention extends to the use of slit-film polymer in the manufacture of air-cargo nets, and to a method of restraining air freight which comprises securing such freight by means of an air cargo net at least the majority of whose netting lines are made from slit-film polymer.

Tests have been performed on lines made of various materials in straight runs and across joints, and we have found the totally unexpected technical advantage that the presence of a joint has a much reduced deleterious effect on the ultimate tensile strength of a line when that line is made from a slit film polymer.

It will be appreciated that the strength of a net is the strength of its weakest part. In consequence, for a given (film-forming) composition, because its use in slit-film form has the surprising technical advantage of increasing joint strength at net intersections, it is also possible for a lighter line to be used for the same strength of net: thus commercially significant weight savings may be made. Alternatively, or in addition to this advantage of weight saving, the invention allows a wide variety of materials to be used for forming the net and these materials may themselves be selected for their inherent properties. One such property is cost.

It is presently believed that the achievement of the principal advantage of this invention, namely increased strength across the joints between the lines of the net is attributable to the use of slit-film polymer and that the achievement of that advantage does not depend on the chemical nature of the polymer used nor on the form of joint, whether that be a knotted or interpenetrating joint, nor does it depend on the line construction, whether that be braided, woven or twisted cord, or webbing strap. It is of course possible that the precise extent of the advantage afforded may depend on one or more of those three factors.

A preferred class of materials for forming the slit-film polymer consists of polyolefins and polyalkenes, which may be substituted or not. Excellent results have been achieved using polypropylene; other materials which it is believed may be used include high density polyethylene, and other film-forming polymers including polyamides, polyesters and other addition polymers or copolymers. It is noteworthy that the advantages of using a slit-film polypropylene cord do not depend on the chemical composition of the material since those advantages are not achieved by the use of a cord made from multi-filament polypropylene.

While joints in the net may be formed in any convenient manner such as knotting or, for example, by chemical or adhesive bonding or even by welding, it is preferred that at least the majority of net joints are interpenetrating joints where each of two intersecting lines of the net passes as a body through a hole in the other respective intersecting line.

The preferred form of line is a braided cord, preferably a coreless braided cord, though woven cord or twisted cordage, especially twisted cordage formed by twisting an even number of strands if interpenetrating joints are to be used, may also be employed, as may woven webbing.

The adoption of the present invention, in at least some of its most preferred embodiments allows the achievement of various other advantages as set out below.

Polyolefins and polyalkenes may readily be produced in a range of colours. This permits nets to be manufactured and colour-coded according to for example their strength rating and/or to other customer requirements. For example an air freight carrier might prefer to have its nets coloured in a particular way to deter unauthorised use of its own nets by a competitor.

Materials can be produced and used which have desirable bending stiffness characteristics. Air cargo nets are quite bulky items and when spread out flat, a fairly large net within the standard range of sizes currently available commercially may be as much as eight or more metres in length and breadth. It will be appreciated that such nets are not always treated with the greatest of care in a shipping warehouse, and that they may simply be thrown into a corner after removal from a pallet. One particular problem which can thus arise is that of tangling. Increasing the stiffness of the netting can militate against tangling. Of course there is a practical limit to any increase in stiffness: it must still be possible conveniently to manipulate the net over a load, and it must be possible to stow the net reasonably compactly when it is not in use.

Materials particularly in view may also be modified by the inclusion of flame-retardants, though test results show that this may not be necessary, at least in the case of polypropylene.

Nets formed from a slit film polymer in accordance with the invention have, as compared with previously proposed nets, a higher net joint strength for a given line tensile strength.

Such slit film polymer nets, especially when formed of a polyolefin or polyalkene may also have an improved abrasion and snag resistance, and a reduced tendency to fray during manufacture. An inherently high abrasion resistance in use is particularly desirable. In order to achieve a satisfactory abrasion resistance when using multi-filament polyamide or polyester braided cord as used hitherto, we have found it necessary to subject the net material to treatment with an agent which promotes abrasion resistance. By adopting the present invention, an inherent satisfactory abrasion resistance can be achieved by suitable choice of material, and thus such a treatment, and any consequential treatment steps, can be avoided, and this significantly simplifies production of the nets.

Further advantages which can be achieved by suitable choice of material include improved resistance to cutting, and improved water resistance, whether by direct absorption or by wicking.

In the accompanying drawings,

Figure 1 shows a detail of a corner of a preferred embodiment of air cargo net;

Figure 2 shows a plan view of a particular embodiment of air cargo net; and

Figure 3 illustrates two lines knotted together using a sheet bend.

In Figure 1, the netting line 1, 2 is of slit-film polymer here constituted by braided or plaited cord. The joint between two netting line portions 1, 2 is generally indicated at 3. It will be seen that each line portion 1, 2 is formed with a through hole, and that the first line portion 1 passes through the hole in the other line portion 2, while that other line portion 2 passes through the hole in the first line portion 1. The two line portions thus interpenetrate, and as shown in the figures, the two line portions which

intersect at a joint each pass as a body through the hole in the other, and they are angled back on themselves to form a secure non-slip junction at which the respective line portions are in contact between said holes. Thus, as shown in Fig. 1, the two lines 1, 2 are each doubled back on themselves to form the joint and can contact each other in the space between the holes.

The holes in the line portions can conveniently be made by hand using a marline spike during the net making process, that is, as each joint is formed, and the resulting joint 3 is a secure non-slip junction.

The holes can be conveniently made after pulling on the lines to draw the respective holes into a position adjacent each other.

The net shown in Fig. 1 includes an optional border cord 4 extending around its periphery and this makes a number of joints such as 5 with portions such as 6 of the netting line, and it will be noted that at the joint 5, the border cord 4 and netting line portion 6 each pass through a hole in the other. In the case of a joint generally designated 7 in Fig. 1, the netting line portion 8 is simply looped around the border cord 4.

A joint 9 (Fig. 1) between two portions of the same netting line is formed in the same way as the joint 3.

Nets intended for use as cargo nets to anchor loads onto pallets are suitably made from a coreless braided or plaited line having a breaking strength of about 1,000kgf to 2,000kgf or 10kN to 20kN. They may be made cruciform in shape with a central panel area approximately equal to the size of a pallet in conjunction with which it is desired to use the net, and four rectangular panel portions or lobes projecting therefrom for a distance equal to the maximum height to which such a pallet is to be loaded.

Such a cruciform net is shown in Fig. 2 and may be made of a size suitable for restraining loads on an aircraft cargo pallet measuring for example 125 inches (3.175m) by 88 inches (2.235m), the cargo being stackable to a height of 118 inches (3m). To this end, the net has a central panel 10 measuring 121 ½ inches by 84½ inches (3.1 × 2.15m), and has integral lobes 11, 12 projecting from its long sides and integral lobes 13, 14 projecting from its short sides. Each lobe would project 118 inches (3m) from the central panel 10. Of course the net may be made in different sizes to fit differently sized pallets. An optional border cord 4 for receiving attachment means which attach the net to a pallet extends around the net and would usually be of a material which is stronger than the inner net-forming lines. In some embodiments, such border cord 4 is confined to the end edges of the lobes 11, 12, 13, 14. The additional strength of the border cord enables that cord to accommodate the loading forces applied thereto by the load on the pallet. A single line 15 (emboldened in the drawing) leads from the centre of the border of the lobe 11 in zigzag manner in the direction of arrow A (compare Fig. 1) across the full width of the net to the centre of the border of the opposite lobe 12. The centre of this line 15 is joined at a joint 5 with the border cord 4 along the edge of the lobe 11, and leads across the net, making joints such as 3 with adjacent lines, and making joints such as 9 with other portions of itself. At the border of the opposite lobe 12, the line is spliced into itself or into the border cord 4 as represented at 16.

A second representative line 17 is shown leading across the net in the same direction. This line 17 is similarly joined by its centre to the border cord at the edge of the lobe 11, but as it crosses the net, this line 17, in addition to making joints such as 3 with adjacent lines and joints such as 9 with other portions of itself, also makes joints such as 5 with the border cord running up the side of the lobe 11.

A third representative line 18 is also shown, and this line extends, again in zigzag manner, again in the direction of arrow A, across a lobe 13 formed on a shorter side of the central panel 10.

It is also possible to form a net having a central panel with a single line passing from one side thereof to the other side thereof in an unbroken zigzag manner, then attaching, by suitable attaching means, a plurality of wing sections, or lobes to that central panel section to form the cruciform shape shown in Fig. 2. Each, or at least one, of the wing sections, or lobes, can also have at least one line which passes from one side thereof to the other side thereof in an unbroken zigzag manner.

Tying lines 19 are attached to the net at the corners 20 of the central panel 10 of the net, that is, at the re-entrant angles of the cruciform shape. By interlacing the tying line 19 at each corner 20 of the central panel 10 with the margins of the two sides of the lobes leaving that corner, after the net has been placed over a load on a cargo pallet, it is possible to ensure that the net is closed down the corners of the load.

It is known to form a net in this way from multi-filament polyester or polyamide braided cord. A net formed in this way is considerably stronger in certain directions than a knotted net made of the same line. It has been found that when a knotted multi-filament polyester or polyamide cord net is tensioned, the breaking strain of the net is substantially independent of the relative directions of the tensile stress and the lines. Thus, supposing that Fig. 1 showed a knotted multi-filament polyester or polyamide cord net, the breaking strength of the net in the directions of the arrows A and B would be substantially the same. Knotting a net has been found to reduce its breaking strength to a figure approaching 50% of the integrated breaking strengths of its individual lines, even where such lines run the full width of the net.

This is not the case in a net having interpenetrating joints as shown in the drawing even when those are made from multi-filament polyester or polyamide cord. In a net having the interpenetrating joints actually shown in Fig. 1, line portions run the full width of the net in the direction of the arrow A, and in this direction, the breaking strength of the net can be as high as 95% of the integrated breaking strengths of the line or lines from which it is made. In the direction of the arrow B however, because there is no continuous line portion running all the way across the net, the breaking strength of the net may be as low as 45% of the integrated breaking strengths of the line or lines. This figure is lower than that in the corresponding direction B for a knotted but otherwise similar net.

While it is often possible to orient such a net so as to take particular advantage of its greatly increased breaking strength in the direction in which the line or lines run, this is not always possible, and it is desired to promote the strength of the net in the direction of the arrow B.

Tests have been made on various lines to investigate their suitability for the manufacture of air cargo nets.

These materials were as follows

Comparative Line 1 (CL1)

This line was a braid of multi-filament polyester yarn. The material was tested untreated and treated with an Abrasion Resistance Agent (ARA) designed to promote the abrasion resistance of the braided line.

Comparative Lines 2 and 3 (CL2 and CL3)

These lines were formed from braided polypropylene multi-filament yarn. The materials were tested untreated. The materials were not subjected to the full test schedule since their straight tensile strength efficiencies were no

real improvement over the material currently used commercially (treated CL1), and because their resistance to snagging and abrasion were too low to make them of any practical value for use in the manufacture of cargo nets.

Comparative Line 4 (CL4)

This line was a second braid of multi-filament polyester yarn, similar to that of Comparative Line CL1. The material was tested untreated.

Example 1

The line of Example 1 was a braid made from slit-film polypropylene to a nominal diameter of 10mm obtained from a first manufacturer.

Example 2

The line of Example 2 was a braid made from slit-film polypropylene to a nominal diameter of 8mm obtained from the first manufacturer.

Example 3

The line of Example 3 was a braid made from slit-film polypropylene to a nominal diameter of 10mm obtained from a second manufacturer.

Example 4

The line of Example 4 was a braid made from slit-film polypropylene to a nominal diameter of 12mm obtained from a third manufacturer.

Example 5

The line of Example 5 was a braid made from slit-film polypropylene to a nominal diameter of 12mm obtained from the first manufacturer.

Example 6

The line of Example 6 was a four strand rope made from slit-film polypropylene to a nominal diameter of 10mm obtained from the first manufacturer.

The various lines were tested in various ways to ascertain the following properties:
Ultimate tensile strength, straight pull
Tensile strength, across a reverse joint

The samples were tested in accordance with BS5F100 using a 150kN Denison tensile tester with bollard jaws, effective gauge length 1m. The samples were conditioned in the test room for at least 16 hours prior to testing under standard laboratory conditions (19° ± 2°C and 65 ± 5% relative humidity).

In order to test strength across an interpenetrating or "knotless" joint (compare Figure 1), the two limbs of one line (1) were connected to one bollard of the test rig while the two limbs (2) of the other line were connected to the other bollard.

In order to test strength across a knotted joint, two lines 100, 200 were knotted together using a sheet bend as shown in Figure 3. The two limbs of one line 100 were connected to one bollard of the test rig, while the two limbs of the other line 200 were connected to the other bollard of the test rig.

The results are shown in the following Tables 1 and 2.

Also in the Tables, the efficiency of the line is expressed in terms of its strength per unit weight, in this instance kgf at breaking divided by the mass in grams per metre length.

It is to be noted that the untreated braids CL1, CL2, CL3 and CL4 exhibited an unacceptably low resistance to snagging and to cutting. The surprisingly high ultimate tensile strength of the braids of Examples 1 and 2 when measured across an interpenetrating joint permits those lines to be used in an air cargo net and to achieve a higher strength of net than the CL1, CL2, CL3 and CL4 lines while using a less expensive material which offers a number of other important practical advantages.

WICKING

The tendency of three of these braids to take up water by wicking was also tested. Braid samples were suspended vertically over methylene blue, and the speed at which wicking took place on initial dipping of the braids into the dye was noted as was the height of dye travel after 3 hours. The untreated braid CL1 exhibited fast initial wicking and the height of dye travel after 3 hours was 43cm. The treated braid showed slow initial wicking with a height after 3 hours of 19cm. The braid of Example 1 exhibited no wicking even after 3 hours. This is of considerable practical importance since in use in wet weather, a cargo net on a loaded pallet may well be exposed to rain while it is awaiting loading onto an aircraft, or an edge of the net may trail into a puddle. Any take-up of rainwater could add considerably to the weight of the net.

The lines of Examples 2 to 6 similarly exhibit very low or negligible wicking.

SNAGGING

Various types of line have also been subjected to a snagging test which consists in pulling the line over a cylindrical surface on which is fixed a snag. Untreated braids CL1 and CL4 snagged badly and had many loops pulled out from the body of the braid. Braids CL2 and CL3 also snagged

very badly. The treated CL1 and the lines of Examples 1 to 6 showed no visible evidence of snagging after being pulled over the surface five times.

The treated and untreated braids CL1 and the lines of Examples 1 to 6 were also assessed for their resistance to cutting. One end of each line was tied to a frame, the braid was held under tension and it was cut with scissors and with a craft knife of the type sold under the Trade Mark STANLEY. There was little difference between the cuttability of the CL1 to 4 braids, but the braids of Examples 1 to 6 were noticeably more difficult to cut, whether with scissors or with the knife.

TABLE 1 (Knotless Intersection)

Line	ARA	Ultimate Tensile Strength				Weight (mass/unit length)	Efficiency $U.T.S./Weight$		$Jnt./Str.$ %
		Straight		Across joint			Straight	Across joint	
		kgf	kN	kgf	kN	g/m			
CL1	No	1309.2	*12.84*	941.4	*9.23*	23.25	56.3	40.5	71.9
CL1	Yes	1162.7	*11.40*	919.4	*9.02*	24.32	47.8	37.8	79.1
CL2	No	1242.0	*12.18*	1204.0	*11.81*	25.14	49.4	47.9	96.9
CL3	No	1513.0	*14.84*	1385.0	*13.59*	32.14	47.1	43.1	91.5
Ex. 1	No	1162.0	*11.40*	1141.0	*11.19*	28.28	41.1	40.3	98.2
Ex. 2	No	1042.3	*10.22*	1089.1	*10.68*	22.51	46.3	48.4	104.5
Ex. 3	No	1324.0	*12.99*	1523.0	*14.94*	34.82	38.1	43.7	115.03
Ex. 4	No	1636.0	*16.05*	1820.0	*17.85*	48.01	34.1	37.9	111.25
Ex. 5	No	1643.0	*16.12*	1723.0	*16.90*	36.44	45.1	47.28	104.87
Ex. 6	No	1626.0	*15.95*	1616.0	*15.85*	44.92	36.2	36.0	99.4

TABLE 2 (Knotted Intersection)

Line	ARA	Ultimate Tensile Strength				Weight (mass/unit length)	Efficiency $U.T.S./Weight$		Knot/Str. %
		Straight		Across knot			Straight	Across knot	
		kgf	kN	kgf	kN	g/m			
CL2	No	1242.0	*12.18*	1150.0	*11.28*	25.14	49.4	45.7	92.6
CL3	No	1513.0	*14.84*	1774.0	*17.40*	32.14	47.1	55.2	117.3
CL4	No	1361.9	*13.36*	996.5	*9.78*	22.4	60.8	44.5	73.2
Ex. 1	No	1162.0	*11.40*	1145.0	*11.23*	28.28	41.1	40.5	98.5
Ex. 2	No	1042.3	*10.22*	1043.0	*10.23*	22.51	46.3	46.3	100.1
Ex. 3	No	1324.0	*12.99*	1394.0	*13.68*	34.82	38.1	40.0	105.3
Ex. 4	No	1636.0	*16.05*	1934.0	*18.97*	48.01	34.1	40.3	118.2
Ex. 5	No	1643.0	*16.12*	1701.0	*16.69*	36.44	45.1	46.68	103.5
Ex. 6	No	1626.0	*15.95*	1534.0	*15.05*	44.92	36.2	34.15	94.3

CLAIMS

1. An air cargo net, at least the majority of whose netting lines are made from slit-film polymer.

2. The use of slit-film polymer in the manufacture of air-cargo nets.

3. A method of restraining air freight which comprises securing such freight by means of an air cargo net at least the majority of whose netting lines are made from slit-film polymer.

4. The invention of any preceding claim, wherein said polymer is a polyolefin or a polyalkene, which may be substituted or not.

5. The invention of any preceding claim, wherein said polymer is a polypropylene or high density polyethylene.

6. The invention of any preceding claim, wherein lines of the air cargo net are joined together at interpenetrating joints where each of two intersecting lines of the net passes as a body through a hole in the other respective intersecting line.

7. The invention of any preceding claim, wherein said slit film polymer is formed into a braided cord for forming the air cargo net.

Application No:	GB 9905847.1	**Examiner:**	Dave McMunn
Claims searched:	1-7	**Date of search:**	24 May 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): B8H (HKE, HQL). B5B (BCE).

Int Cl (Ed.6): B66C 1/12. B60P 7/08.

Other: ONLINE : WPI, EPODOC, JAPIO.

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
Y	GB 2,239,211 A (TAMA). See e.g. Fig 6	1-6
Y	GB 1,443,830 (BRIDPORT-GUNDRY). See Figs	1-7
Y	EP 0,247,952 A1 (GENNESSON). See e.g. Fig 1	1-6
Y	US 4,270,657 (BAYON). See Figs	1-5,7
Y	US 4,000,344 (DILBEY). See Figs	1-7
Y	WPI Abstract Accession No. 93-240318 & JP5163630 - See abstract	1-7

X Document indicating lack of novelty or inventive step	**A** Document indicating technological background and/or state of the art.
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